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Time History Solution Program - L225 (TEV126)

Volume II: Supplemental System Design
and Maintenance Document

A. Tornallyay, R. E. Clemons, and R. I. Kroll

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Volume II: Supplemental System Design
and Maintenance Document

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under Contract NAS1-13918



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CONTENTS

1.0 SUMMARY	1
2.0 INTRODUCTION	1
3.0 PROGRAM DESIGN AND STRUCTURE	3
3.1 Overlay (L225,0,0) - L225vc	5
3.2 Overlay (L225,1,0) - SORT	9
3.3 Overlay (L225,2,0) - ANAL	13
3.4 Data Bases	18
4.0 EXTENT OF CHECKOUT	28
REFERENCES	30

1.0 SUMMARY

Program L225 (TEV126) is structured as three overlays, one main and two primary. Input into the program is made via cards and magnetic files (tapes or disks). Output from the program consists of printed results and magnetic files containing vectors suitable for plotting.

Although L225 serves as a module of the DYLOFLEX system, it can be operated as a standalone program. Subroutines used by L225 include routines embedded in the program code, routines obtained from the standard FORTRAN library, and routines obtained from the DYLOFLEX library.

2.0 INTRODUCTION

The computer program L225 (TEV126) can be used as either a standalone program or as a module of a program system called DYLOFLEX (see fig. 1) which was developed for NASA under contract NAS1-13918 (ref. 1). Because of the DYLOFLEX contract requirements developed in reference 2, a program was needed to calculate the time histories of different airplane responses to discrete excitations using frequency response data calculated in a power spectral density solution. An existing program^{1,2} was revised according to DYLOFLEX specifications³ to make it compatible with other modules of the DYLOFLEX system.

The objective of this volume is to aid those persons who will maintain and/or modify the program in the future. To meet this objective, the following items are defined in detail:

- Program design and structure
- Overlay purpose and description
- Input, output, and internal data base descriptions
- Test cases used in program checkout

¹Smith, B. E.; and Johnson, M. R.: *Discrete Gust Convolution Program (TEV126)*. Boeing document D6-29668TN, January 1969.

²Every, J. S.: *Frequency Response Function Sorting Program (TEV126, Link1, DIG1)*. Boeing document D6-29669TN, vol. II, April 1971.

³Clemmons, R. E.: *Programming Specifications for Modules of the Dynamic Loads System to Interface with FLEXSTAB*. NASA contract NAS1-13918, BCS-G0701, September 1975.
(Internal Document)

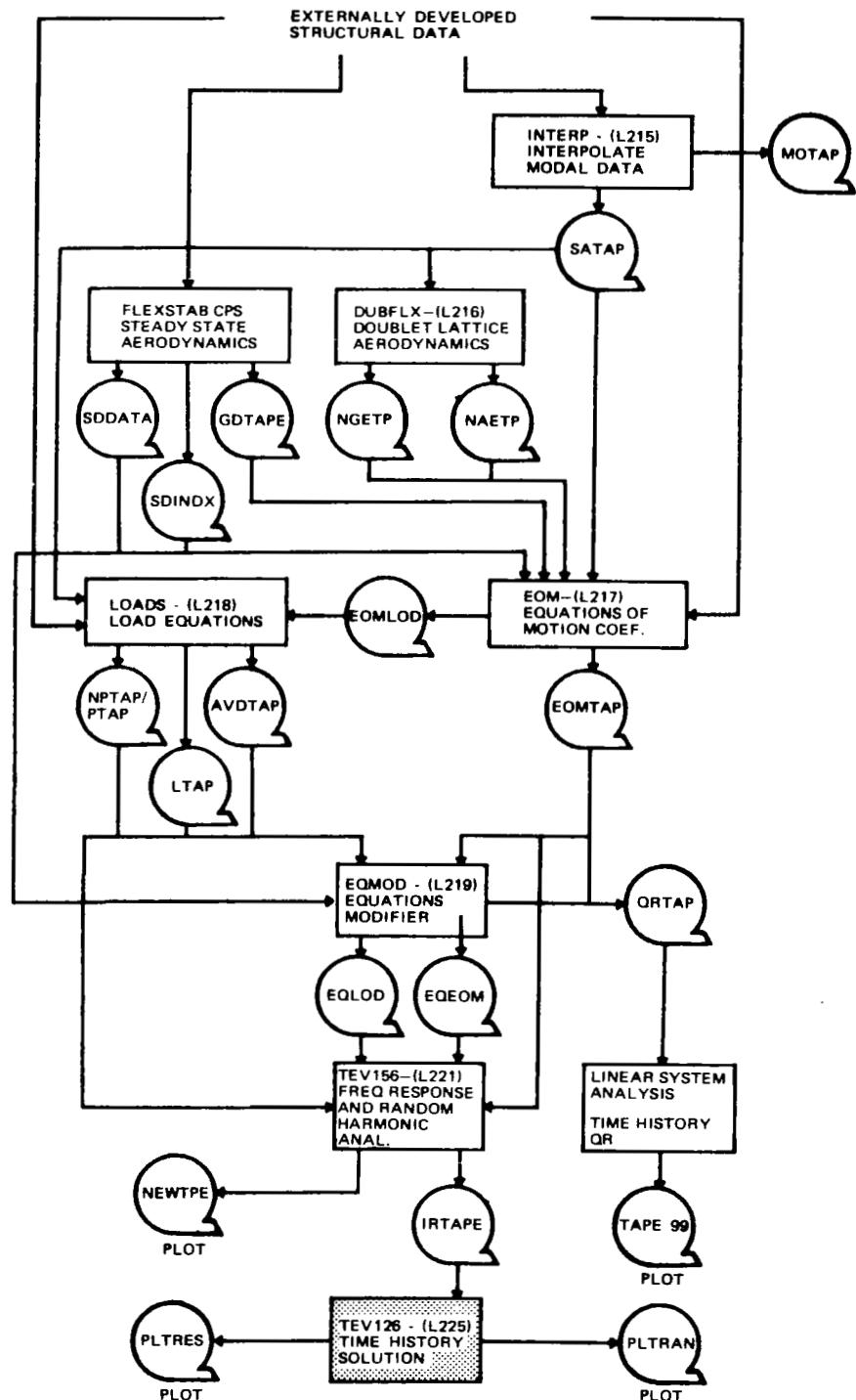


Figure 1. -- DYLOFLEX Flow Chart

3.0 PROGRAM DESIGN AND STRUCTURE

The program is structured as a system of three overlays, one main overlay and two primary (see fig. 2).

Main overlay (L225,0,0) L225vc

Primary overlay (L225,1,0) SORT

Primary overlay (L225,2,0) ANAL

The main overlay L225 reads data cards that direct the execution of the primary overlays. It also aids communication between the primary overlays via labelled common blocks.

The 1,0 primary overlay SORT reads the frequency response functions from cards or tape, sorts those functions the user wishes to use in the time history convolution, and saves the desired response functions on a temporary scratch file.

The 2,0 primary overlay ANAL reads the sorted frequency response functions from the scratch file generated by SORT. The retained functions are then convoluted with a forcing function chosen by the user. Output can be in the form of printed time histories, printed maximum and minimums, or tapes containing data vectors suitable for plotting.

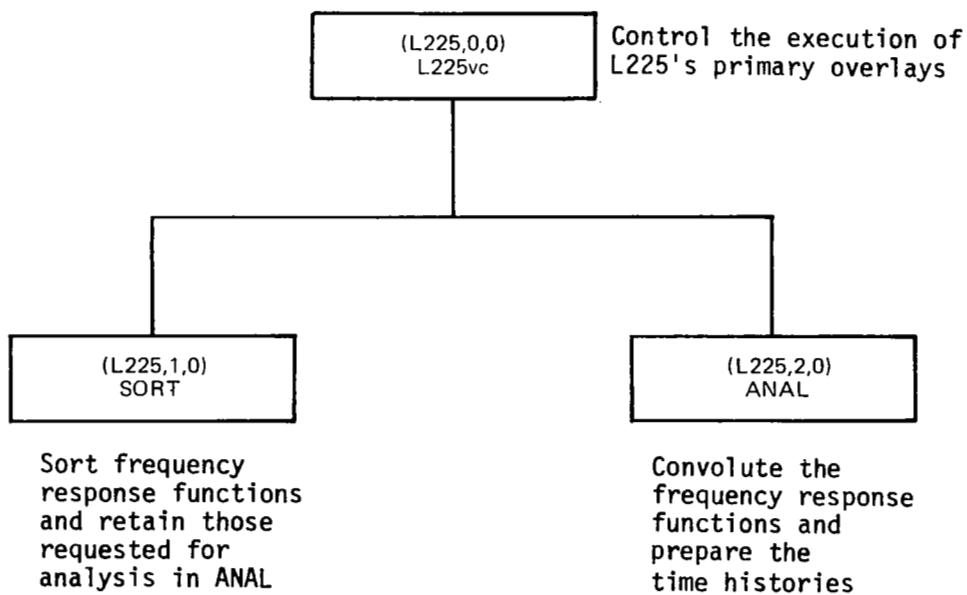


Figure 2.—Overlay Structure of L225 (TEV126)

The input and output for each of the overlays is shown in figure 3.

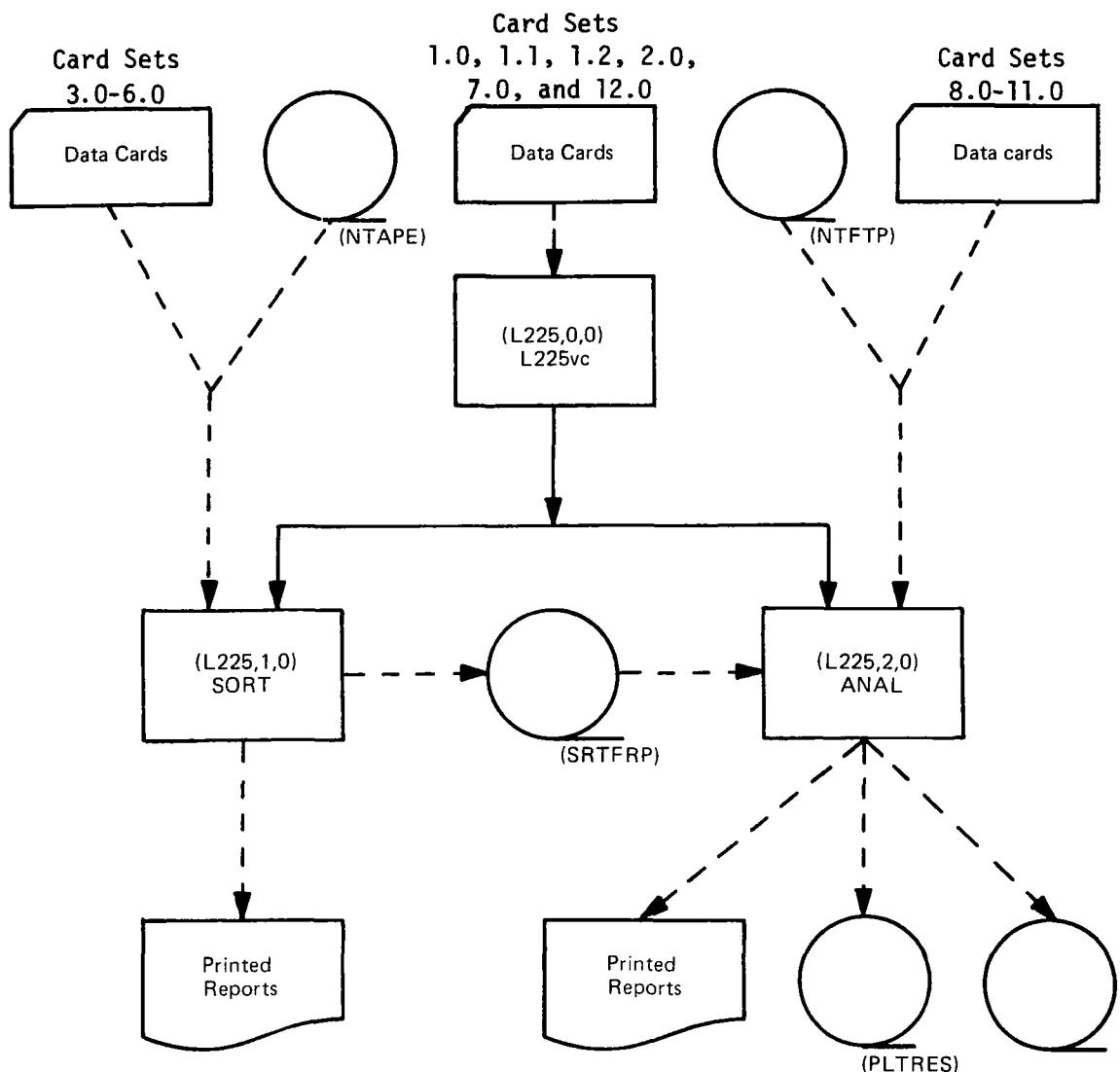


Figure 3.—Input/Output of L225 Overlays

Although L225 (TEV126) serves as a module of the DYLOFLEX system, it can be operated as a standalone program. When the program is run by itself, it becomes the user's responsibility to generate input data in the format required by L225 (TEV126). (See volume I of this document for the required data and formats.)

This program requires subroutines that are not part of the L225 code. Some routines are automatically obtained from the standard FORTRAN library when the program is loaded. Others, however, are stored in the DYLOFLEX alternate subroutine library which must be declared at the time of loading. Subsequent sections describe each overlay separately and contain tables displaying the routines called and the library in which they are located. Each subroutine has only one entry point.

This volume describes the program in a macro sense. A more detailed discussion appears in the comments contained in the program source code. Each routine contains a preface describing the routine's purpose, author, analytical steps, modification history, input data, output data, glossary of variables, and a list of other routines called. Embedded within the executable code are comments labeling each section and explaining logical branches.

3.1 OVERLAY (L225,0,0) – L225vc

The main overlay of L225 (TEV126) is L225vc, where v is a letter indicating the program version, and c is an integer number indicating the correction number which applies to the v version.

Purpose of L225vc

L225vc performs certain bookkeeping tasks, directs the execution of the primary overlays, and aids communication between primary overlays via labeled common blocks.

Analytical Steps of L225vc

L225vc performs its task in the following six steps:

1. The subroutine PRGBEG is called to place the program header on the printed output.
2. A data card is read. It must begin with \$TIME to ensure that the card input file is correctly positioned. If it does not contain \$TIME, execution is terminated.
3. A program directive card is read, printed, interpreted, and acted on according to the following logic:

If the keyword is \$TITLE, jump to step 3 again.

If the keyword is \$CHECKout, set the checkout switch and jump to step 3 again.

If the keyword is \$SORT, jump to step 4.

If the keyword is \$ANAL, jump to step 5.

If the keyword is \$QUIT jump to step 6.

4. Overlay (L225,1,0) is called. When it is finished, program control returns to step 3.
5. Overlay (L225,2,0) is called. When it is finished, program control returns to step 3.
6. Subroutine PRGEND is called. This subroutine places the program termination message on the printed output.

If fatal errors are discovered, the program prints a diagnostic and jumps to step 6.

The macro flow chart of this overlay is shown in figure 4. The subroutines called are displayed in table 1.

Table 1.—Routines Called by L225vc

OVERLAY (L225,0,0)
PROGRAM L225vc

ANAL - OVERLAY (L225,2,0)
FETAD +
FETDEL +
IRDCRD +
PRGBEG +
PRGEND +
RETURNF +
SORT - OVERLAY (L225,1,0)

+ indicates a routine on the DYLOFLEX alternate subroutine library DYLIB.

All others are local to L225 (TEV126).

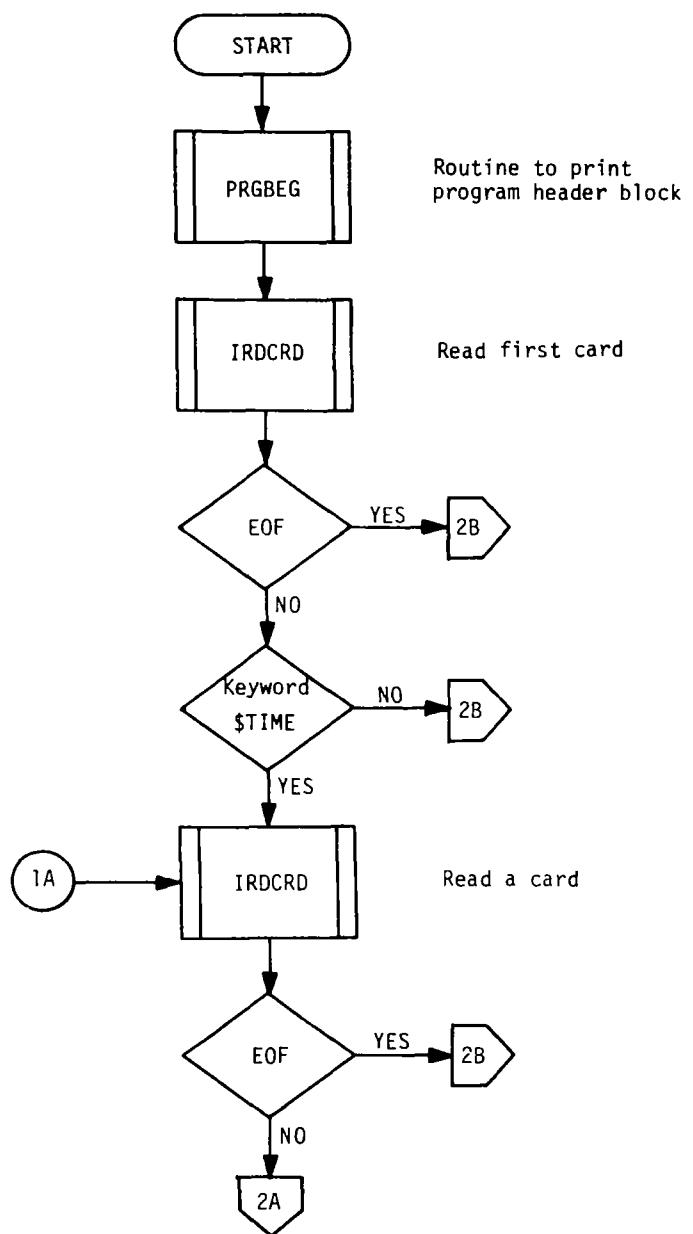


Figure 4.—Macro Flow Chart of Overlay (L225,0,0) L225vc

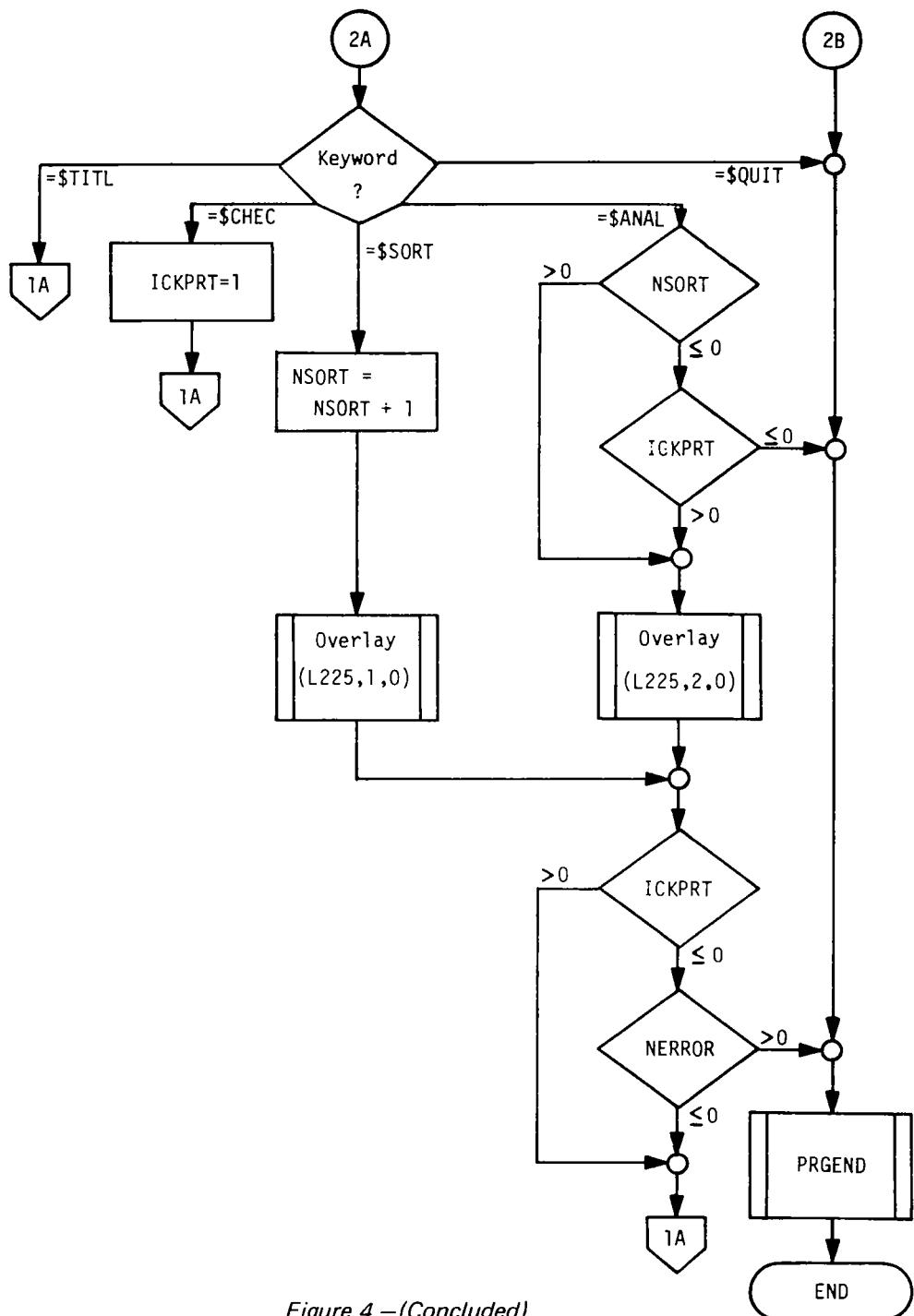


Figure 4.—(Concluded)

I/O Devices of L225vc

L225vc reads program directive cards and writes them on the printed output file. All other I/O accomplished by L225 (TEV126) is done in the primary overlays.

3.2 OVERLAY (L225,1,0) - SORT

Purpose of SORT

SORT is the first primary overlay in program L225 (TEV126). SORT reads frequency response function data from either cards or a magnetic file (tape or disk), selects responses requested via card input, and writes a file containing the response functions to be analyzed in ANAL, the (L225,2,0) overlay.

Analytical Steps of SORT

SORT performs its task in the following steps:

1. Subroutine RDSZSC is called to read the sorting instruction cards (card sets 3.0 through 6.0).
2. Subroutine CARDIN or TAPEIN is then called to read the first set of responses from cards or tape, respectively.
3. Subroutine WRITAP is called to write the selected responses on the scratch file SRTFRP.

If the input response functions are on cards, control is shifted to step 6.

4. Subroutine TAPEIN is called again to read the second set of responses from tape.
5. WRITAP is called to write the second set of selected responses on SRTFRP.
6. Control is returned to the calling program, the main overlay L225vc.

When input is made via the standard input file NTAPE (see file map shown in vol. I), the input response functions (generalized coordinates and loads) are processed in two separate passes. Steps 2 and 3, the generalized coordinates (Q's) are read, sorted, and written on the scratch file SRTFRP. Steps 4 and 5, the load frequency response functions are read, sorted, and written on SRTFRP. This procedure is used because it saves core storage and allows the user to specify Q's and loads separately.

The responses on NTAPE are defined for one frequency at a time; i.e., the tape consists of a set of arrays containing all the responses (both Q's and loads) at frequency one, followed by a similar set of arrays at frequency two, and so on until the final set of arrays at frequency NFREQ. With the first call of TAPEIN, the real and imaginary parts of the generalized coordinate arrays are stored in the rows of the RESR and RESI matrices in SORT. These matrices are of size NFREQ by NRMAX, where NRMAX is the

larger of the two numbers, the number of generalized coordinates, or the number of loads. It then becomes the task of WRITAP to select the columns of RESR and RESI to be written onto SRTFRP for analysis in ANAL. The second call to TAPEIN repeats this process for the load frequency response functions.

If the response functions are input via cards, the subroutine CARDIN is only called once. Response functions are read from cards and stored in successive arrays of size 1 by NFREQ. In this case, NRMAX is the sum of the number of responses analyzed (see card input for SORT in vol. I). No sorting is required with card input. The responses are written directly on the scratch file SRTFRP.

Figure 5 shows the macro flow chart of the SORT overlay. The subroutines called are displayed in table 2.

Table 2.—Routines Called by SORT

OVERLAY(L225,1,0)

PROGRAM SORT

CARDIN	{ IRDCRD +
FNDKEY +	
LOCF *	
RDSZSC	{ IRDCRD + NAMFIL +
REQFL +	
TAPEIN	{ FETAD + FETDEL + READTP +
WRITAP	WRTETP +

* indicates a routine on the FORTRAN subroutine library.
+ indicates a routine on the DYLOFLEX alternate subroutine library DYLIB.

All others are local to L225 (TEV126).

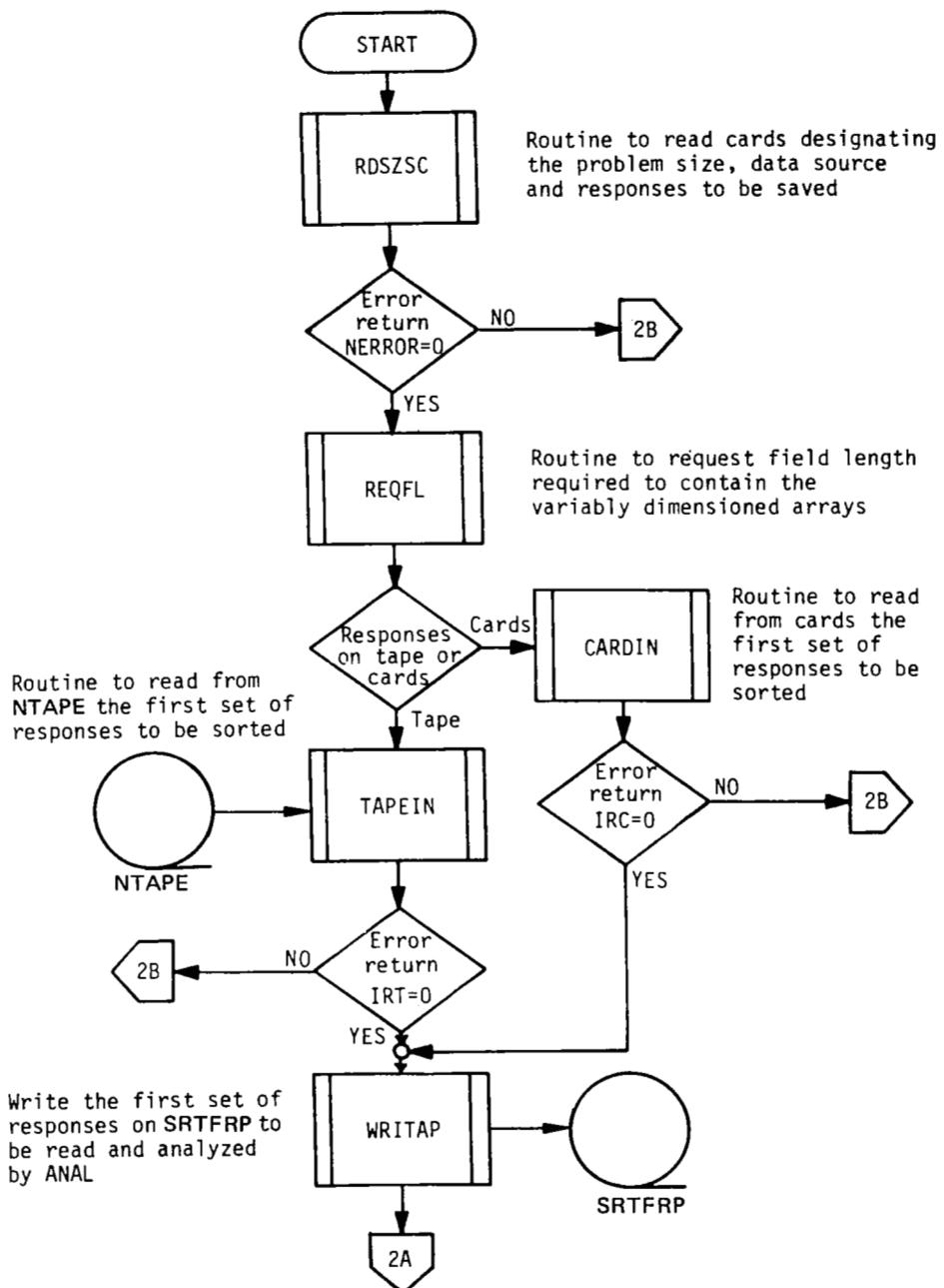


Figure 5.—Macro Flow Chart of Overlay (L225,1,0) SORT

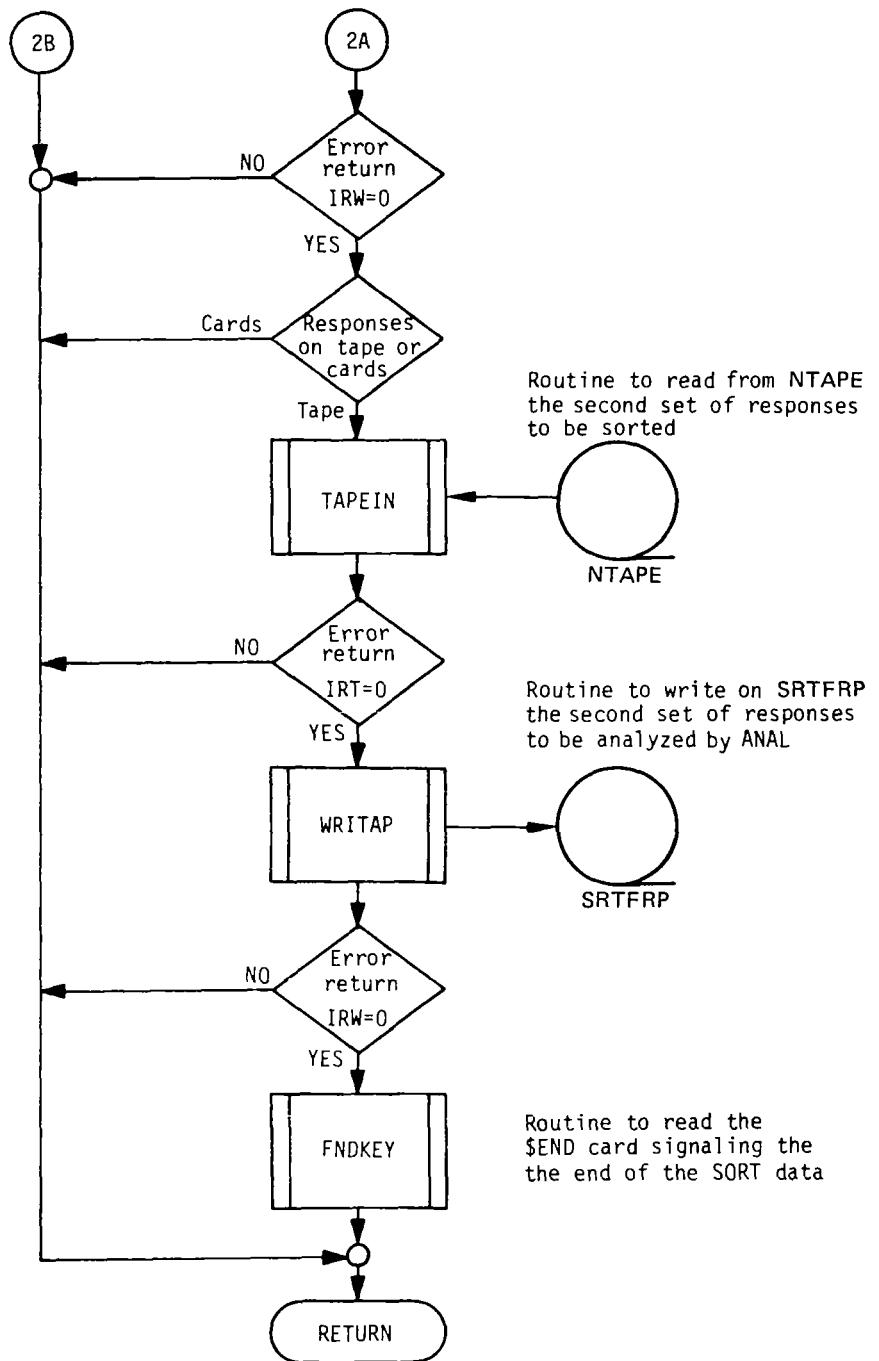


Figure 5.—(Concluded)

I/O Devices of SORT

SORT reads card input instructions (card sets 3.0 through 6.0) and reads the input responses from either cards (cards 4.1 through 4.4) or a magnetic file, NTAPE.

SORT prints a summary of the items sorted and writes the items to be analyzed onto the magnetic file SRTFRP.

3.3 OVERLAY (L225,2,0) - ANAL

Purpose of ANAL

ANAL is the second primary overlay in program L225 (TEV126). ANAL reads card input data describing the type of forcing function to be used in convoluting the frequency response functions and defining the types of output results desired. It reads the frequency response functions from the scratch file SRTFRP, generates the required time histories, prints the items requested, and optionally writes data files for plotting.

Analytical Steps of ANAL

ANAL performs its task in the following steps:

1. Subroutine CARDRD is called to read card input instructions.
2. Frequencies are read from the scratch file SRTFRP.
3. Subroutine INITAL is called to define execution control data.
4. Subroutine TFRESP is called to define the transform of the forcing function.

Steps 5 through 8 are repeated until all frequency response functions on SRTFRP have been processed.

5. The real and imaginary parts of a frequency response function(s) are read from SRTFRP.
6. The subroutine CONVOL is called to evaluate the convolution integral.
7. The requested output is printed.
8. The requested plot files are prepared.
9. If plot files were generated, an end-of-file is written on them and then returned to the calling program.

The macro flow chart for this overlay is shown in figure 6. The subroutines called are displayed in table 3.

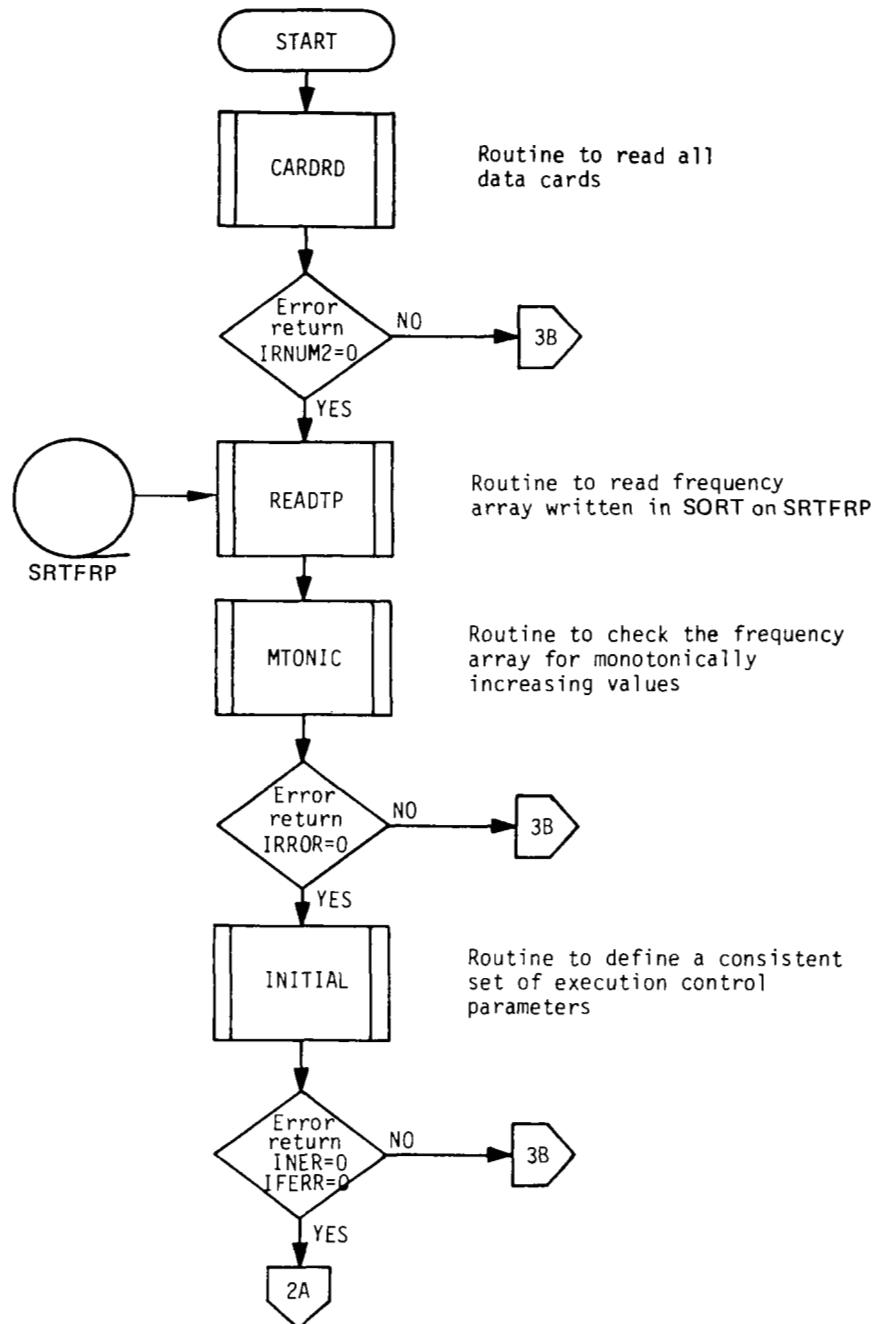


Figure 6.—Macro Flow Chart of Overlay (L225,2,0) ANAL

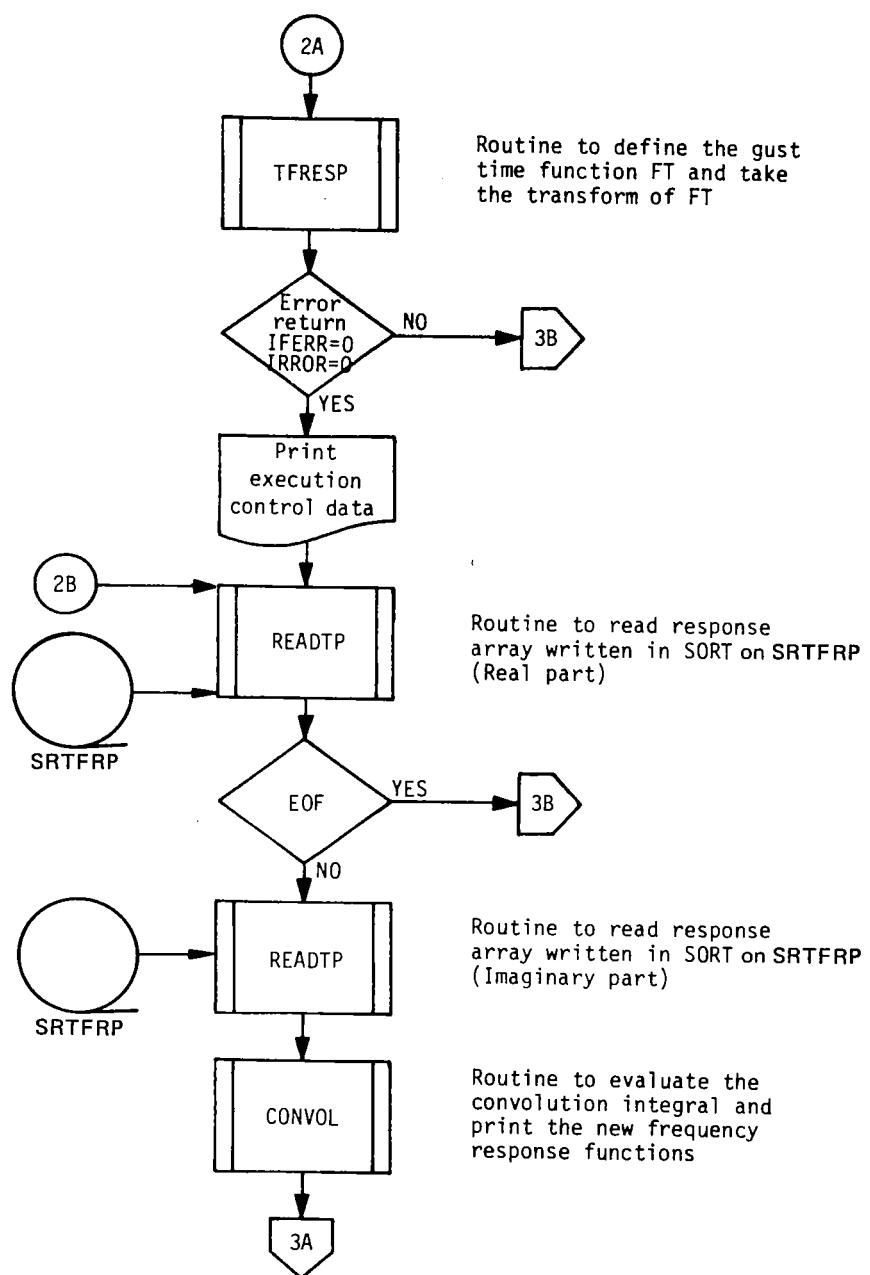


Figure 6.—(Continued)

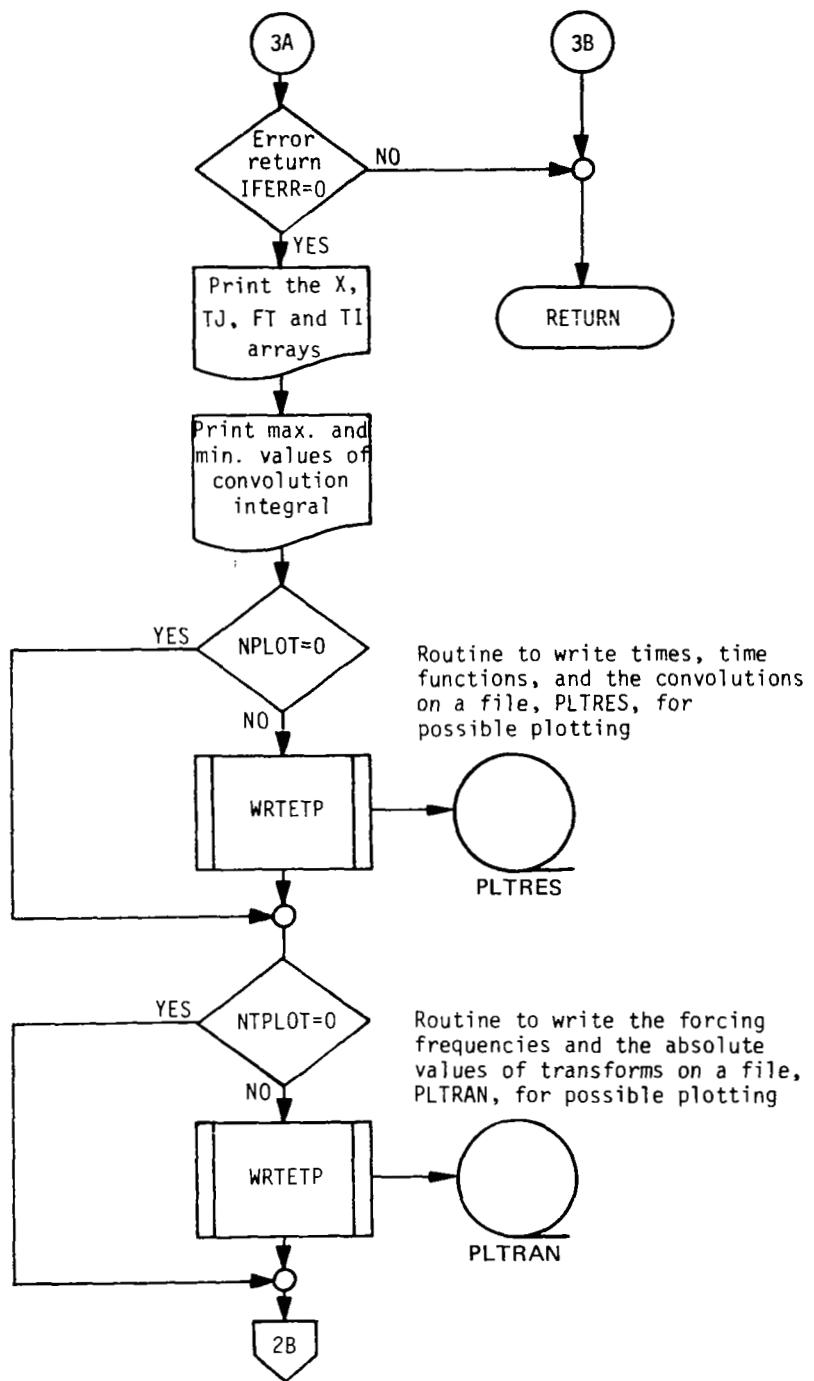


Figure 6.—(Concluded)

Table 3.—Routines Called by ANAL

OVERLAY(L225,3,0)

PROGRAM ANAL

CARDRD { FETAD +
 FETDEL +
 IRDCRD +
 MTONIC
 NAMFIL +
 READ TP +

CONVOL { INVERS { HARM
 LINEAR

INITIAL { EQUAL { HARM
 LESS
 SET

MTONIC
READTP +

TFRESP { LINEAR
 TRANSF { HARM

WRTETP +

* indicates a routine on the FORTRAN subroutine library.

+ indicates a routine on the DYLOFLEX alternate subroutine library DYLIB.

All others are local to L225 (TEV126).

I/O Devices of ANAL

ANAL reads card input instructions (card sets 8.0 through 11.0), frequency response functions from the temporary file SRTFRP, and optionally reads a forcing function array from the file NTFTP.

ANAL prints the time histories and frequency response functions requested via card input. It also optionally writes the plot data files PLTRES and PLTRAN.

3.4 DATA BASES

L225 (TEV126) data bases include input and output files plus internal scratch files and common block storage.

3.4.1 INPUT DATA

Input data are from two sources: cards and magnetic files.

Card Input Data

For a complete description of all the card input formats, see section 6.5.1 in volume I of this document (User's Guide).

Magnetic File Input Data

For a complete description of the magnetic file input data, see section 6.5.2 in volume I of this document (User's Guide).

3.4.2 OUTPUT DATA

Output data may be of two types: printed and magnetic files.

Printed Output Data

For a complete description of the printed output data, see section 6.6.1 in volume I of this document (User's Guide).

Magnetic Files (Tape or Disk)

For a complete description of the magnetic file output data, see section 6.6.2 in volume I of this document (User's Guide).

3.4.3 INTERNAL DATA

Two methods are used to pass data from one portion of the program to another: a scratch (temporary) storage file and labeled common blocks.

Magnetic File (Scratch Disk File)

The SORT program, overlay (L225,1,0), reads frequencies and frequency response functions from cards or tape, selects responses requested by the user, and writes them on the scratch file SRTFRP to be read and processed by ANAL, overlay (L225,2,0).

SRTFRP is generated by L225 (TEV126) and released by the program when a run terminates normally. If a fatal error occurs, the subroutine RETURNF is not called, and the file will still exist after execution is terminated. This may be helpful for debugging purposes.

SRTFRP is written with the subroutine WRTETP and read with the subroutine READTP. Both routines are described in reference 1. The contents of SRTFRP are displayed in table 4.

Table 4.—Contents of SRTFRP - A Temporary Scratch File

<u>Array Size</u>			where:
NFREQ	X 1	{FREQ}	
NFREQ	X 1	{RESR} ₁	{FREQ} = frequencies at which responses are defined
NFREQ	X 1	{RESI} ₁	
NFREQ	X 1	{RESR} ₂	{RESR} _i = real parts of frequency response i.
NFREQ	X 1	{RESI} ₂	
		:	
		:	{RESI} _i = imaginary parts of frequency response i.
NFREQ	X 1	{RESR} _{NRQ}	
NFREQ	X 1	{RESI} _{NRQ}	NFREQ = number of frequencies.
NFREQ	X 1	{RESR} ₁	
NFREQ	X 1	{RESI} ₁	NRQ = number of generalized coordinate (q's) frequency responses retained for analysis.
NFREQ	X 1	{RESR} ₂	
NFREQ	X 1	{RESI} ₂	
		:	
		:	
NFREQ	X 1	{RESR} _{NRL}	
NFREQ	X 1	{RESI} _{NRL}	NRL = number of load frequency responses retained for analysis.
<u>End-of-File</u>			

Common Blocks

Table 5 displays the common blocks used in the program and the overlays in which they are used.

LABLED common blocks are used for communication between the main and primary overlays, and for communication between routines in a primary overlay. Block names and contents are described in table 6.

BLANK common is used in the primary overlay SORT as a variable-length working storage area. The main program of the overlay calculates the area required for arrays in the various subroutines and passes a first-word address and variable dimension for each array through the subroutine's calling sequence.

Table 5.—Common Blocks in Each Overlay

COMMON BLOCK OVERLAY	ERRORS	INOUT	MASK	SRTFIL	CHKPRT	RWBUFF	BLANK
(L225,0,0) L225 vc	X	X	X	X			
(L225,1,0) SORT	X	X		X	X	X	X
(L225, 2,0) ANAL	X	X	X	X		X	

Table 6.—Contents of Common Blocks

LABELLED COMMON NAME: <u>ERRORS</u>					
DESCRIPTION: Contains the number of fatal errors diagnosed					
NO.	VARIABLE	TYPE	DIM.	ENG. NOMENCLATURE	DESCRIPTION
1	NERROR	I	1		Number of fatal errors diagnosed by the program.

Table 6.—(Continued)

LABELLED COMMON NAME: <u>INOUT</u>					
DESCRIPTION: Contains standard input/output file names					
NO.	VARIABLE	TYPE	DIM.	ENG. NOMENCLATURE	DESCRIPTION
1	INFIL	I	1		The name of the card input file (=5)
2	IUTFIL	I	1		The name of the printed output file (=6)
3	IPFIL	I	1		The name of the punch file (=7)
					<u>NOTE:</u> IPFIL is not actually used inside L225.

Table 6.—(Continued)

LABELLED COMMON NAME: <u>MASK</u>					
DESCRIPTION: <u>Contains a word used to mask keywords</u>					
NO.	VARIABLE	TYPE	DIM.	ENG. NOMENCLATURE	DESCRIPTION
1	MASK5	H	1		A masking word used to retain only the first five characters of a ten-character word (=7777 7777 7700 0000 0000B)

Table 6.—(Continued)

LABELLED COMMON NAME: <u>SRTFIL</u>					
DESCRIPTION: <u>Contains the name of the L221 scratch file</u>					
NO.	VARIABLE	TYPE	DIM.	ENG. NOMENCLATURE	DESCRIPTION
1	ISORT	H	1		Name of the L225 (TEV126) scratch file. (=6LSRTFRP)

Table 6.—(Continued)

LABELLED COMMON NAME: <u>CHKPRT</u>					
DESCRIPTION: <u>Contains an option requesting checkout printing</u>					
NO.	VARIABLE	TYPE	DIM.	ENG. NOMENCLATURE	DESCRIPTION
1	ICKPRT	I	1		<p>Option requesting checkout intermediate printing.</p> <p>In SORT</p> <p>=0 no checkout printing.</p> <p>=1 print responses input to SORT.</p> <p>=2 print frequencies and responses input to SORT and output from SORT.</p>
					<p>In ANAL</p> <p>=0 no checkout printing.</p> <p>=1 print the time functions from the analysis routine.</p> <p>=2 print time functions plus the responses and frequencies from SORT</p>

Table 6.—(Continued)

LABELLED COMMON NAME: <u>RWBUFF</u>					
DESCRIPTION: <u>Contains a buffer array for the subroutine READTP</u>					
NO.	VARIABLE	TYPE	DIM.	ENG. NOMENCLATURE	DESCRIPTION
1	IBL	H	1		Keyword telling the routine READTP that the buffer size is in word two (=8HBUFSIZE)
2	IB2	I	1		Length of the following buffer.
3	RWBUFR	R	250		The buffer used by READTP to read the input frequency and response matrices. Size of buffer limits the size of arrays read.

Table 6.—(Concluded)

<p>LABELLED COMMON NAME: <u>Blank Common</u></p> <p>DESCRIPTION: <u>Contains the SORT variably-dimensioned arrays</u></p>					
NO.	VARIABLE	TYPE	DIM.	ENG. NOMENCLATURE	DESCRIPTION
1	FREQ	R	NFREQ		The array of frequencies at which the frequency responses are defined.
2	RESR	R	(NFREQ, NRMAX)		The array to contain the real part of the frequency responses. Each column represents a frequency and each row represents a response.
3	RESI	R	(NFREQ, NRMAX)		The array to contain the imaginary parts of the frequency responses. Each column represents a frequency and each row represents a different response.

4.0 EXTENT OF CHECKOUT

L225 (TEV126) was checked out with 17 different data cases using frequencies and frequency response functions generated by L221 (TEV156) (ref. 3). The results from L225 (TEV126) match those produced by an earlier version of the program.¹

One pass through SORT, the 1,0 primary overlay, sorted the response and saved them on a temporary scratch file SRTFRP. Then, the 2,0 primary overlay ANAL was called 17 times, once for each data case.

A separated deck of card input data was used to trigger most of the program's diagnostics. \$CHECKOUT (card 1.2) was included in the deck to allow the program to continue processing even though fatal errors have occurred.

A complete list of card input data, control cards, and printed output for all test cases is saved on the program's master tape and packaged with the latest program listing. Table 7 provides a summary of the option combinations tested.

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October 1977

¹See footnotes 1 and 2 in section 2.0.

Table 7.—Summary of Checkout Cases

		OPTIONS USED IN SAMPLE RUNS																
FUNCTION	TYPE	STEP		TRIPLE STEP	SINE WAVE		(1-COS)			THREE ONE		NON-STANDARD						IMPULSE
		1	2		4	5	6	7	8	9	10	11	12	13	14	15	16	
	Time (T)	0.0	0.5	.5,1,0,1.5	0.0,.82	0.0,.82	0.0,.82	0.0,.82	0.0,.82	0.0,-,3.0	-	-	-	-	-	-	-	0.0
	Amplitude (AMP)	1.0	1.0	1.0,3.0,2.0	1.0	1.0	1.0	1.0	1.0	1.0,-,3.0	-	-	-	-	-	-	-	1.0
	Period (PERIOD)	-	-	-	.82	.82	.82	.82	.82	.82	-	-	-	-	-	-	-	-
TAPE	Source of	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	YES
CARDS	time functions	-	-	-	-	-	-	-	-	-	YES	YES	YES	YES	YES	YES	-	-
OPTIONS		YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	(IPTION)	6	6	6	5	6	6	6	6	6	1	2	3	4	7	8	6	6
	(M)	10	10	10	10	10	10	10	10	10	0	6	6	6	6	6	6	10
	(TMAX)	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	(DELTAT)	0.0	0.0	0.0	.001	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.05	0.05	0.05	0.0
	(FHARM)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(FMAXB)	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
CONJUGate		-	-	-	-	-	-	-	-	-	YES	-	-	-	-	-	-	-
INTEGRATE	COMPLEX	YES	YES	YES	YES	YES	-	-	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	REAL	-	-	-	-	-	YES	-	-	-	-	-	-	-	-	-	-	-
	IMAGINARY	-	-	-	-	-	-	YES	-	-	-	-	-	-	-	-	-	-
PRINT changes		YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	-
OUTPUT	STANDARD	-	-	-	-	-	YES	YES	-	-	YES	YES	YES	YES	YES	YES	YES	-
	NON-Standard	YES	YES	YES	YES	YES	YES	-	YES	YES	YES	YES	YES	YES	YES	YES	YES	-
	TIME	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	-	-	YES
PRINT	INTERpolated	YES	YES	-	-	-	-	-	-	-	-	-	-	-	-	-	-	YES
	ALL Transfer	-	-	-	-	-	-	-	-	-	YES	-	-	-	-	-	-	-
	MAXIMUM	YES	-	YES	-	YES	-	-	-	YES	-	-	-	-	-	-	-	YES
SELECT		-	-	YES	-	-	-	-	-	YES	-	-	-	-	-	-	-	-
	(NPTS)	-	-	1000	-	-	-	-	-	28	-	-	-	-	-	-	-	-
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16 Abstract <p>This document describes the time history solution program L225 (TEV126). The program calculates the time responses of a linear system by convoluting the impulsive response functions with the time-dependent excitation function. The convolution is performed as a multiplication in the frequency domain. Fast Fourier transform (FFT) techniques are then used to transform the product back into the time domain to obtain response time histories. Program usage and a brief description of the analysis used are presented in volume I of this document. Volume II contains a description of the design and structure of the program to aid those persons who will maintain and/or modify the program in the future.</p>			
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